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(54) HIGH STRENGTH FERRITIC HEAT RESISTANT STEEL

(57)Abstract:

PROBLEM TO BE SOLVED: To provide high strength ferritic heat resistant steel having excellent creep rupture strength as the material for high temperature used for boiler tubes for heat generation, turbine parts, chemical plant apparatus, nuclear powder plants or the like.

SOLUTION: As to the high strength ferritic heat resistant steel, in an Fe based alloy in which ≥ 90% of the matrix is always formed of a ferritic phase in all temperature ranges of the melting point or lower, an intermetallic compound is age-precipitated. Alternatively, in the steel, sufficient solid solution treatment is performed before aging, so that the uniform and fine age-precipitation of an intermetallic compound is promoted. Further, the steel has a composition containing one or more kinds selected from ≤40% Cr, ≤10% Si, ≤10% Al, ≤10% W and ≤10% Mo, and the balance Fe with inevitable impurities. Alternatively, the steel further contains ≤ 0.05% C and ≤0.05% N, and further contains one or more kinds selected from V, Nb, Ti, Ta, Mn, B, Ni, Co, Cu and rare earth elements by ≤5% in total.

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CLAIMS

[Claim(s)]
[Claim 1]High intensity ferritic heat resisting steel carrying out the prescription deposit of the intermetallic compound in all the temperature regions below the melting point in a Fe group alloy in which not less than 90% of a matrix always serves as a ferrite phase.
[Claim 2]High intensity ferritic heat resisting steel having performed solution treatment sufficient before prescription and promoting a uniform detailed prescription deposit of an intermetallic compound in the steel according to claim 1.
[Claim 3]High intensity ferritic heat resisting steel containing one sort in less than Mo:10%, or two sorts or more, and consisting of the remainder Fe and inevitable impurities in claim 1 or 2 less than Cr:40%, less than Si:10%, less than aluminum:10%, and W:10% or less.
[Claim 4]High intensity ferritic heat resisting steel decreasing in claims 1-3 to C:0.05% or less and N:0.05% or less.
[Claim 5]High intensity ferritic heat resisting steel containing one sort in V, Nb, Ti, Ta, Mn, B, nickel, Co, Cu, and a rare earth element, or two sorts or more 5% or less in total in claims 1-4.
[Claim 6]High intensity ferritic heat resisting steel, wherein a creep rupture life of 650 ** and 196MPa has in claims 1-4 for 1000 hours or more.
[Claim 7]High intensity ferritic heat resisting steel, wherein a creep rupture life of 700 ** and 196MPa has in claim 5 for 100 hours or more.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the high intensity ferritic heat resisting steel which has the outstanding creep rupture strength in high-temperature-service materials, such as a boiler tube for power generation, a turbine part, a chemical-processing-plant device, and a nuclear reactor in operation.
[0002]
[Description of the Prior Art]Conventionally, by the component system which produces a martensitic transformation from austenite, in the matrix which mainly consists of martensitic structure, the ferritic heat resisting steel used as a high-temperature-service material distributes carbide, a nitride, or carbon nitride minutely, and aims at improvement in high temperature creep strength.
There are many examples of a report.
However, in order dislocation density is dramatically high since these are the materials accompanied by a martensitic transformation, and to cause rapid recovery by the pyrosphere of a 600-700 ** level, There is a limit in improvement in creep strength, and fracture time is 10 hours - about 100 hours in the creep-rupture examination of 650 ** and 196MPa.
[0003]
[Problem(s) to be Solved by the Invention]Although there are some which control a deposit of carbide by making carbon additive-free in JP,2000-248340,A, deposit only an intermetallic compound instead, and plan intensity in recent years, About the matrix, this also adds elements, such as nickel and Co, and makes them martensitic structure, and it is the creep-rupture examination of 650 ** and 120MPa, Fracture time is before or after 2000 hours, 100 hours - about 500 hours are presumed, therefore the test condition of intensity of 650 ** and 196MPa is insufficient. In order to add expensive nickel, Co, etc. so much, there is a problem

that it is very high-cost.

[0004]Although characterized by depositing uniformly the intermetallic compound which shows ferromagnetism and antiferromagnetism in an organization grain by addition of Pd, Pt, etc. in JP,2000-248341,A, About a matrix, add C 0.06 to 0.18% and generation of a delta ferrite is controlled, In [recommend the martensitic structure by the transformation from austenite, and] the creep-rupture examination of 650 ** and 120MPa, Fracture time is about 4000 hours, and on condition of 650 ** and 196MPa, 200 hours - about 800 hours are presumed, and in order that this may also use expensive Pd, Pt, etc. insufficiently [intensity], there is a problem that it is very high-cost.

[0005]

[Means for Solving the Problem]A result to which artificers advanced development wholeheartedly in order to solve a problem which was mentioned above, Reduce austenite generation elements, such as C and N, make ferritizers, such as Cr, W, and Mo, contain, and not less than 90% of a matrix with a Fe group alloy which always serves as a ferrite phase below with the melting point. It is in providing ferritic heat resisting steel excellent in high temperature strength which carried out the prescription deposit of the intermetallic compound which consists of W, Mo, Fe, etc. into the matrix. High intensity ferritic heat resisting steel, wherein a place made into a gist of the invention carries out the prescription deposit of the intermetallic compound in all the temperature regions below (1) melting point in a Fe group alloy in which not less than 90% of a matrix always serves as a ferrite phase.

[0006](2) High intensity ferritic heat resisting steel having performed solution treatment sufficient before prescription and promoting a uniform detailed prescription deposit of an intermetallic compound in steel of the aforementioned (1) statement.

(3) High intensity ferritic heat resisting steel containing one sort in less than Mo:10%, or two sorts or more, and consisting of the remainder Fe and inevitable impurities in the above (1) or (2) less than Cr:40%, less than Si:10%, less than aluminum:10%, and W:10% or less.

(4) The above (1) High intensity ferritic heat resisting steel decreasing in - (3) to C:0.05% or less and N:0.05% or less.

[0007](5) The above (1) High intensity ferritic heat resisting steel containing one sort in V, Nb, Ti, Ta, Mn, B, nickel, Co, Cu, and a rare earth element, or two sorts or more 5% or less in total in - (4).

(6) The above (1) High intensity ferritic heat resisting steel, wherein a creep rupture life of 650 ** and 196MPa has in - (4) for 1000 hours or more.

(7) Be in high intensity ferritic heat resisting steel, wherein a creep rupture life of 700 ** and 196MPa has for 100 hours or more in the above (5).

[0008]

[Embodiment of the Invention]Hereafter, the reason for limitation of the component

composition concerning this invention is explained.
Cr: Cr is effective in formation of a ferrite phase, and corrosion-resistant and oxidation-resistant improvement 40% or less. However, excessive addition made the maximum 40% in order to degrade toughness.
Si, aluminum:10%or less Si, and aluminum are effective in deoxidation, formation of a ferrite phase, and oxidation-resistant improvement. However, excessive addition made the maximum 10%, respectively in order to degrade toughness.
[0009]W, Mo:10%or less W, and Mo are effective in formation of a ferrite phase, solid solution strengthening, and precipitation strengthening as an intermetallic compound. However, the maximum was made into 10% from a viewpoint of stopping the cost hike by excessive addition, respectively.
C, N:0.05%or less C, and N were the elements no necessity is [elements] in particular in this invention, and since they fully needed to control the martensitic transformation and needed to aim at improvement in intensity, they made the maximum 0.05%, respectively.
[0010]5%or less V, Nb, Ti, and Ta are effective in formation of a ferrite phase in total in one sort in V, Nb, Ti, Ta, Mn, B, nickel, Co, Cu, and a rare earth element, or two sorts or more. Mn is effective in deoxidation. B is effective in improvement in hot-working nature and creep strength. Although nickel, Co, and Cu are effective in corrosion-resistant improvement, excessive addition promotes a martensitic transformation and degrades creep strength. The rare earth element is effective in improvement in creep strength. However, the effect showed up enough at 5% by each sum total, and made the maximum 5% from a certain thing.
[0011]
[Example]Hereafter, an example explains this invention concretely. The 100-kg experiment steel ingot of the chemical entity shown in Table 1 was ingoted, cogging was carried out to a round bar 20 mm in diameter, solution treatment of water cooling shown in Table 1 was performed, and age heat treatment of air cooling of 700 ** - one h was carried out after that. Using the above-mentioned material, the creep-rupture specimen with a diameter of 6 mm of a parallel part was produced, and the creep-rupture examination on the conditions of 650 ** and 196MPa was carried out. As a result, as shown in Table 1, as for this invention steel, it turns out conventionally desirably that the dramatically outstanding fracture life of 3000 hours or more is shown for 1000 hours or more to steel being the fracture time which is 10 hours - about 100 hours.
[0012]
[Table 1]

表 1

No	化 学 成 分 (mass%)								マトリックス中のフェライト面積率 (%)	クリープ試験(650℃、196MPa) における破断時間(h)	固溶化条件(いずれも水冷)	備考
	C	Si	Mn	Cr	Mo	W	N	その他				
1	0.007	0.15	0.22	8.43	3.22	2.17	0.002		98	2211	1100 ℃×5min	本発明鋼
2	0.005	0.05	0.11	11.78	2.19	1.96	0.001		99	3137	1100 ℃×5min	
3	0.003	0.31	0.25	3.98	4.95	6.22	0.012		100	6515	1100 ℃×5min	
4	0.008	0.35	0.31	5.22	3.25	1.25	0.008		100	1085	なし(鍛伸まま)	
5	0.012	2.55	0.25	17.35	1.97	1.95	0.024		100	3517	1100 ℃×5min	
6	0.025	1.55	0.75	16.55	0.33	2.34	0.018	Al:1.43	92	1544	950 ℃×10min	
7	0.038	0.25	0.21	17.12	3.19	4.38	0.026	V:0.21	97	5624	1100 ℃×5min	
8	0.048	0.32	0.31	19.22	2.45	5.31	0.009		98	3937	1100 ℃×5min	
9	0.065	0.51	0.25	23.35	5.32	5.19	0.035	B:0.003	100	7123	1100 ℃×5min	
10	0.055	0.05	0.09	32.25	4.71	6.21	0.042		100	6149	1100 ℃×5min	
11	0.005	0.31	1.32	9.33	1.03	0.94	0.006		100	1228	850 ℃×10min	
12	0.004	0.21	0.19	9.12	1.55	1.54	0.012		100	1623	950 ℃×10min	
13	0.011	0.43	0.35	12.78	2.34	1.92	0.019	Ta:0.11, Y:0.4	98	3006	1100 ℃×5min	
14	0.022	0.29	0.31	11.56	0.01	3.21	0.011		100	2108	1100 ℃×5min	
15	0.038	0.25	0.21	18.56	4.32	0.01	0.011	V:0.18, Nb:0.21	100	2580	1100 ℃×5min	
16	0.042	1.43	0.22	23.51	0.02	6.32	0.021	Ti:0.50, Ni:0.78	100	4560	1100 ℃×5min	
17	0.062	1.25	0.34	25.12	4.65	6.32	0.034	Al:2.25, Co:0.97, Cu:0.52	100	6613	1100 ℃×5min	
18	0.035	0.30	0.35	11.87	3.67	4.38	0.017		100	3084	1100 ℃×5min	
19	0.012	0.35	0.31	11.29	2.16	2.31	0.023		92	1472	なし(鍛伸まま)	
20	0.014	0.21	0.29	12.11	2.98	3.21	0.018		100	2910	1100 ℃×5min	
21	0.073	0.51	0.61	9.01	1.12	0.01	0.058	V:0.25, Nb:0.41	1	20	1100 ℃×60min	比較鋼
22	0.121	0.23	0.45	2.24	0.01	1.21	0.021	V:0.27, Nb:0.06, B:0.004	0	13	1100 ℃×60min	
23	0.205	0.35	0.30	12.28	1.35	1.23	0.055	V:0.35, Ni:0.95	0	37	1100 ℃×60min	
24	0.201	0.41	0.61	11.98	1.01	1.21	0.052	V:0.24, Nb:0.07, B:0.003	2	67	1100 ℃×60min	
25	0.225	0.32	0.51	12.02	0.21	2.78	0.048	Co:2.51, V:0.20, Nb:0.07	0	42	1100 ℃×60min	
26	0.092	0.61	0.52	9.12	2.35	1.21	0.045	V:0.21. Nb. 0.43, Ta:0.07	0	59	1100 ℃×60min	

注) マトリックス中のフェライト面積率：１１００℃水冷時に判定

[0013]Thus, since this invention steel has very low conventionally [which a matrix becomes from a martensitic transformation in order not to be accompanied by a martensitic transformation] dislocation density compared with steel, at the time of 600-700 ** heating at high temperature, it becomes possible to reduce rapid recovery of it substantially. By carrying out the prescription deposit of the intermetallic compound, sufficient control of the movement toward a rearrangement is still attained, and, as a result, this invention steel has the dramatically outstanding creep strength which is not considered with conventional ferritic heat resisting steel. Specifically in the creep-rupture examination of 650 ** and 196MPa, 3000 fracture hours or more are shown desirably fracture 1000 hours or more. This is equivalent to 10 times - 100 times as much fracture time as the ferritic heat resisting steel in which the matrix actually used consists of martensitic structure now.

[0014]In a solution treatment state or the state of being equivalent to it, this invention steel is possible also for considering it as the low hardness of 98 or less HRB, and excellent also in processability. In the state of prescription, it is also possible to consider it as the hardness of 33 or more HRC, and it is possible to also set ordinary temperature tensile strength to 1000 or more MPa. In order to fully obtain strengthening by prescription deposit, control of not less than 900 ** solution treatment or the rolling temperature equivalent to it, and the cooling rate after rolling, etc. are effective. As for prescription temperature, about 600-750 ** is effective.

[0015]

[Effect of the Invention]As stated above, the outstanding effect which can provide the ferritic heat resisting steel which has austenite and the creep strength which excelled more than equivalent by this invention is done so.

[Translation done.]